SPRINGFLOW ASSESSMENT OF WHITE SULPHUR SPRINGS

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Abstract. In January 1997, the Suwannee River Water Management District initiated a water level monitoring program at White Sulphur Springs near White Springs, Florida. The program's purpose was to assess the historical relationship between flow from the springhouse as a function of Floridan aquifer and Suwannee River levels. Anecdotal evidence indicates that discharge from White Sulphur Springs has decreased significantly over time. Springflow status was reviewed and data were analyzed to assess the quantity of springflow relative to aquifer head and river level. Regression analysis shows a strong relationship between differential head (Floridan aquifer elevation minus springpool elevation) and springflow when river conditions permit flow to occur.

Using the above criteria, hindcasting was performed to April 1982, beginning date for continuous Floridan aquifer monitoring near the spring. The analysis indicates that between April 1982 and December 1996, the spring flowed roughly 40 percent of the time.

INTRODUCTION

In January 1997, the Suwannee River Water Management District, in cooperation with Stephen Foster State Folk Culture Center of the Florida Department of Environmental Protection, initiated a water level monitoring program in and around White Sulphur Springs in the town of White Springs in northern Florida (Figures 1 and 2). The purpose of the monitoring was to assess the impact of groundwater and surfacewater levels on flow from the springhouse, located in SFCC (Figure 3). In addition to water levels, flow status at the springhouse was assessed (when the spring was discharging, recharging, and stagnant) and periodic discharge measurements were conducted.

A better understanding of how White Sulphur Springs--and by extension other Floridan aquifer springs--responds to fluctuations and trends in surface and groundwater levels will assist water managers in North Florida and southern Georgia to address water availability issues. From a recreational perspective, the assessment of springflow potential is valuable for planners for the determining whether the springhouse can be used for a bathhouse as it was historically.

Anecdotal evidence indicates that discharge from White Sulphur Springs has decreased significantly over time. According to one long-time resident of the town, the spring experienced a decline in sulfur content around 1960, although flows remained stable and the

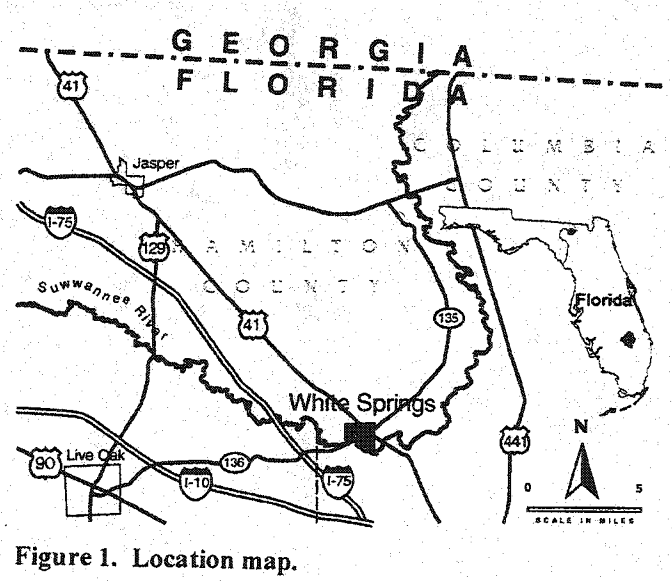

Figure 1. Location map.

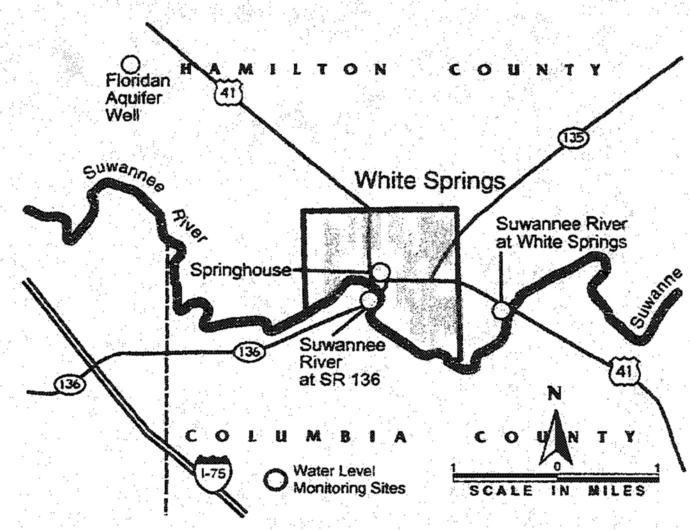

Figure 2. Monitoring locations near White Sulphur Springs.

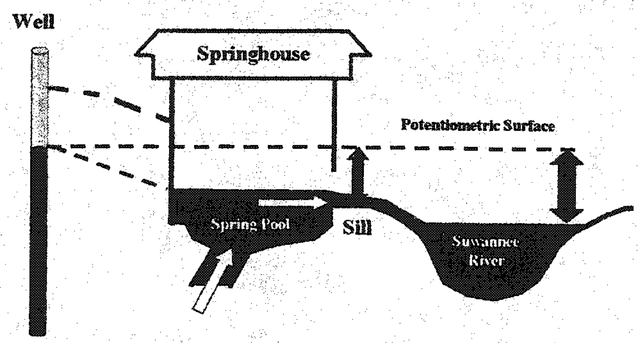

Figure 3. Springflow schematic.

spring discharge had continued during the four-year drought of the mid-1950's (Saunders, 2000). Intermittent water quality monitoring by the USGS confirms the change (Rosenau et al, 1977). A decline in springflow became noticeable in the early 1970's and by the summer of 1977, the spring stopped flowing for the first time. Subsequently, flow stoppages increased in frequency and length (Robertson, 2000).

MONITORING PROGRAM

During the 3-year period from January 1997 through December 1999, water levels from the springhouse pool and the Suwannee River at State Road 136 (SR 136) just upstream of the springhouse were monitored weekly. During the same period, surfacewater level and discharge were measured at the United States Geological Survey gaging station at US 41 on the Suwannee River (USGS, 1999). Groundwater levels were measured at a Floridan aquifer well near Facil, 3 miles northwest of the spring. Monitoring has been conducted continuously at the US 41 bridge since 1927. The Facil well has been monitored continuously since 1982 (Figure 1). Periodic measurements of springflow

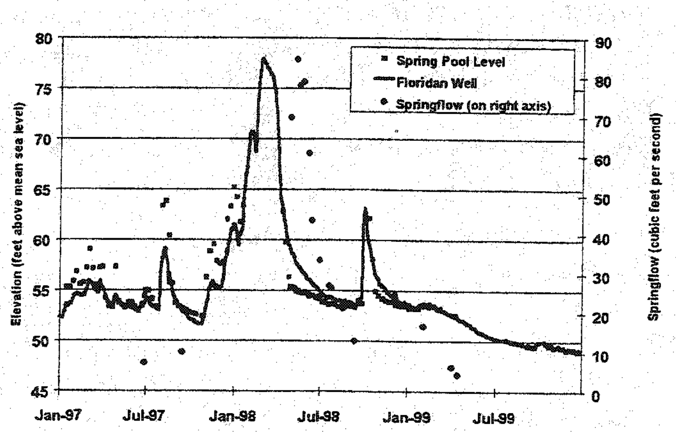

Figure 4. Groundwater, spring pool, and spring discharge data, White Sulphur Springs.

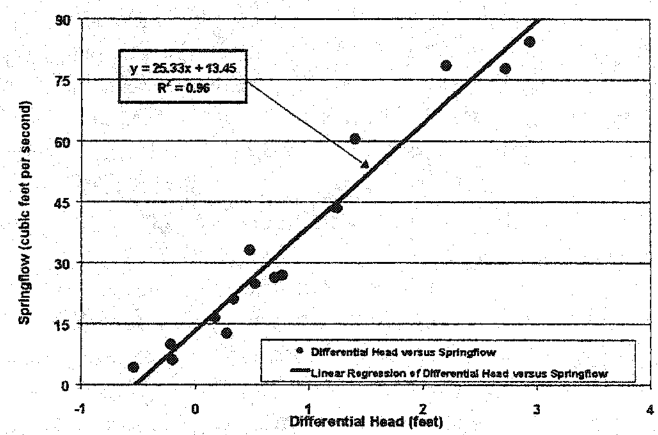

Figure 5. Springflow compared to differential Floridan aquifer head.

were conducted from January 1997 to May 1999, when springflow ceased. Monitoring data is presented in Figure 4. Table 1 provides a summary of spring discharge measurements.

RESULTS

The spring discharge rate relative to groundwater head was examined for the study period. Although the Floridan well is not upgradient of the springhouse, it is roughly at the same isopotentiometric contour. It is the closest Floridan aquifer well with a long-term, high quality data set available for approximating potential head at the spring. Regression analysis shows an excellent linear relationship (r^2 = 0.96) between differential head (well elevation minus springpool

Table 1. Summary of Discharge Measurements from White Sulphur Springs

	Flow		
Date	Cubic feet per second	Million gallons per day	Gallons per minute
07/01/97	7.2	4.7	3231
09/17/97	9.9	6.4	4443
04/30/98	69.7	45.0	31281
05/11/98	84.4	54.5	37879
05/18/98	77.7	50.2	34872
05/26/98	78.7	50.9	35321
06/08/98	60.5	39.1	27152
06/16/98	43.4	28.0	19478
07/02/98	33.3	21.5	14945
07/23/98	26.9	17.4	12073
07/27/98	26.3	17.0	11803
08/21/98	21.1	13.6	9470
09/14/98	12.8	8.3	5745
12/07/98	24.8	16.0	11130
02/04/99	16.6	10.7	7450
04/05/99	6.2	4.0	2783
04/16/99	4.2	2.7	1885
Average	35.5	23.0	15938

elevation) and springflow (Figure 5). Springflow measurements conducted under backwater conditions when the Suwannee River was partially blocking flow at the springhouse opening were ignored. On the basis of the regression relationship, an estimate of daily discharge may be obtained with the regression equation.

By comparing the surfacewater and groundwater monitoring data with the spring data, an assessment of whether or not the spring was flowing during the period of study is possible. In order for the spring to flow from the springhouse, the groundwater elevation at the Floridan well must exceed approximately 51.75 feet above mean sea level (ft-msl). At the same time, the river level at the springhouse (at SR 136) must be less than 52.45 ft-msl (the bottom elevation of the sill of the springhouse) to allow free springflow. In addition, the river must be less than about 55.3 ft-msl for the spring to flow against the river-induced backwater at the springhouse sill (Figure 6). These springflow criteria match up well with visual observations of flow conditions at the springhouse obtained by FDEP staff. On the basis of this assessment, the spring probably flowed 50 percent of the time during the 3-year study period.

Surfacewater level records are not available at the SR 136 bridge prior to January 1997. However, the long-term USGS gage at US 41 two miles upstream of the springhouse allows a longer-term assessment. An offset of -1.6 ft was used to adjust the US 41 river elevation data for an approximation of the river level at SR 136. With this long-term river data and the period-of-record Floridan well levels, an estimate of springflow conditions was made using the regression developed previously. The results indicate that between April 1982 and December 1996, the spring flowed approximately 40 percent of the time.

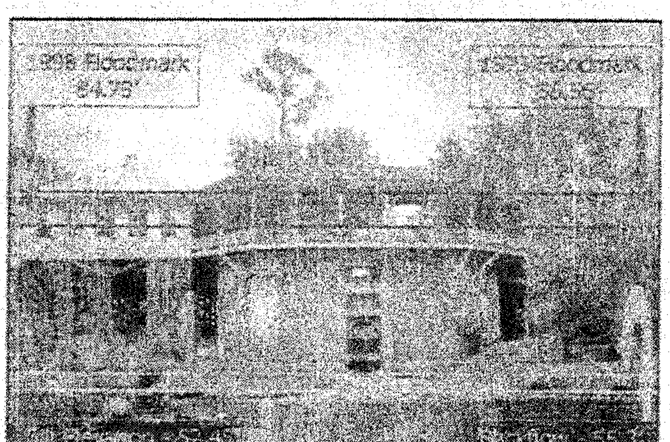

Figure 6. Key water levels at White Sulphur Springs.

Table 2. Estimated Springflow Status - White Sulphur Springs

	Statistical River and Groundwater Level Conditions				
Month	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
January	No Flow	No Flow	Flows	No Flow	No Flow
February	No Flow	Flows	No Flow	No Flow	No Flow
March	No Flow	Flows	No Flow	No Flow	No Flow
April	No Flow	Flows	No Flow	No Flow	No Flow
May	No Flow	Flows	Flows	Flows	No Flow
June	No Flow	No Flow	Flows	Flows	No Flow
July	No Flow	No Flow	Flows	No Flow	No Flow
August	No Flow	No Flow	Flows	No Flow	No Flow
September	No Flow	No Flow	Flows	No Flow	No Flow
October	No Flow	Flows	Flows	No Flow	No Flow
November	No Flow	No Flow	Flows	Flows	No Flow
December	No Flow	No Flow	Flows	Flows	No Flow

As a separate analysis, Table 2 provides a matrix of estimated springflow behavior under consistent, paired river and groundwater level conditions (e.g., both river and groundwater at minimum levels, or both at 50th percentile conditions; USGS 1994 and 1996). Because the river responds more rapidly to rainfall than does the aquifer, river and groundwater levels will not necessarily be synchronous. Groundwater levels tend to lag river levels by 30 to 60 days. Nevertheless, this analysis can provide important insights into typical springflow conditions.

When both groundwater and river levels are low, the spring will not flow since the aquifer head is not sufficient to crest the sill of the springhouse. Conversely, when groundwater and river levels are at maximum levels, the spring will not flow because the river is recharging the aquifer via the spring vent. Under "typical" conditions, defined here as the 50th percentile levels for surfacewater and groundwater, the spring would be expected to flow from May through January. From February through April the river would be elevated enough to block flow.

When water levels depart from the 50th percentile, conditions favoring springflow diminish. Therefore, springflow appears most likely during May-June and October-November—dry periods when the river is likely to be low and the lagged-response rise in the Floridan aquifer from either the winter frontal rains (May-June) or from summer convectional/tropical storm events (October-November) has occurred.

DISCUSSION

In general, springflow and springflow frequency from White Sulphur Springs have diminished over time due to a decline in the potentiometric head in the spring vent. Possible reasons include a change in the spring conduit system, local groundwater withdrawals, or a more regional decline in groundwater levels.

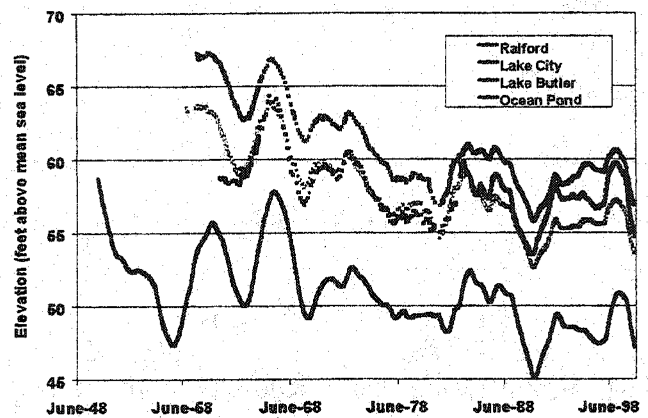

Figure 7. **Regional Floridan aquifer monitoring data.**

Hindcasting, in the manner employed above, assumes overall hydrogeologic conditions have not changed significantly with time. However, this may not be the case with White Sulphur Springs. Review of long-term Floridan aquifer level data as far back as 1948 indicates that the potentiometric surface of the Floridan aquifer is falling in the region.

The four nearest, long-term Floridan aquifer monitoring wells display a declining trend in the regional potentiometric surface over the past 40-50 years (Figure 7). A decline of about 6 feet in the aquifer level since the 1950's can be estimated from the slope of the trend lines for each well. This change could account for the alteration in springflow status.

The impact of reduced aquifer levels on the spring is a potentiometric head not consistently high enough either to crest the springhouse sill, or to overcome periodic inundation by the Suwannee River. However, declining groundwater levels over time have reduced the river level at which springflow ceases and thereby increased the frequency at which higher river levels block springflow.

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